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Integration of ground remote sensing surveys and archaeological excavation to characterize the medieval mound (Scarlino, Tuscany-Italy)

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Key words: GPR; Automatic Resistivity Profiler; geochemical analysis, archaeological excavation; medieval mound; Scarlino

The landscape of Scarlino (Grosseto, Italy) has been studied by the Department of Archaeology (University of Siena) since 1979. The archaeological site was identified in vertical air photos, but the unavailability of GPS devices at the time made location in the field difficult. Aerial photo analysis allowed us to interpret the evidence as a triple enclosure. This paper presents the data collected with magnetic, GPR and Automatic Resistivity Profiler (ARP) surveys with the purpose of opening a new perspective for archaeological research on the landscape around this site, Fig. 1.

In 2005, oblique aerial photographs from low-flying craft identified a clear archaeological cropmark. The feature consists of a triple concentric circular enclosure with traces of a fourth in the centre and a fifth to the left of the latter. Moreover, some parallel linear traces were observed to overlap the enclosure, Fig.1 (Campana *et al.*, 2005). The circular marks can be made to correspond basically to ditches and/or a palisade. The evidence inside and outside the smaller enclosure can be related generically to buildings (Fig.1). Starting from September 2005, several different ground surveys of the site were accomplished: field walking, DGPS (differential global positioning system), magnetic (Overhauser), GPR and ARP® (Automatic Resistivity Profiler). Three archaeological tests were dug in September 2007 to verify the geophysical results.

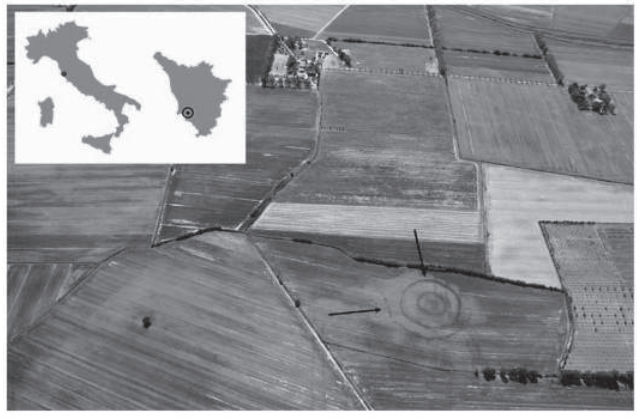

Figure 1: Tuscany. The lowland of Scarlino. Oblique aerial photographs of a distinct archaeological cropmark

The fieldwalking survey was carried out immediately after ploughing and was done in good light conditions and with excellent archaeological visibility, turning up in the end

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effect relatively high quantities of potsherds. Magnetic measurements were carried out immediately after this survey. The measurements have a resolution of 1 m between the profiles and 0.50 m along the lines. The surveyed area, covering 2 hectares, corresponds to features visible in oblique aerial photos. The interpretation of the magnetic map allows several features to be recognized. The map shows three concentric enclosures and in the centre a rectangular feature that can be interpreted as a building.

In the GPR method, a high-resolution data acquisition technique was adopted in order to be able to reconstruct a global view of the investigated subsoil volume. GPR surveys were performed during July 2007, employing a SIR 3000 (GSSI) equipped with a 500 MHz bistatic antenna set to a constant transmitter-receiver offset. Some signal processing and representation techniques were used for data elaboration and interpretation (Goodman *et al.*, 2008; Piro *et al.*, 2003). Time-slices data were created using the spatially averaged square wave amplitudes of the return reflection. These averaged square amplitudes were gridded using a Kriging routine. Some filtering was used to remove the background reflections on field data. For elaboration and representation of GPR data, GPR-Slice software (by D. Goodman) was employed.

Fig. 3a presents a GPR time-slice, at estimated depth of 0.65 m in an area of 50 x 50 m. An analysis of this slice shows that this zone is characterized by the presence of clear anomalies due to many small reflectors (rocks), forming a circular distribution as wall remains. This distribution presents a good match with the magnetic anomalies.

The site was surveyed again in the autumn of 2007, employing an Automatic Resistivity Profiler (ARP© system, developed in France by GEOCARTA, Dabas, 2008). The area surveyed included the site and its surroundings, totalling about 5 hectares in extent.

All the raw data were processed by a 1D median filter along the first transect and then interpolated by a spline bicubic process on a squared mesh (40 × 40 cm for investigation depths of 0-50 cm and 0-100 cm and 50 × 50 cm for the deeper 0-170 cm, Fig. 2). The ARP© data revealed new information for the northern side of the surveyed area, but also permitted information on known features to be integrated. The survey also produced a high resolution DTM of the investigated area.

Surface ground samples for a chemical prospection of the site were taken in the summer of 2007. The samples were recovered from points every 2 m along two lines (N-S) and (E-W) crossing at the centre of the circles. The N-S line is 100 m long and the E-W line 76 m. Furthermore, an area of 50 × 60 m at the centre of the site was sampled using a grid

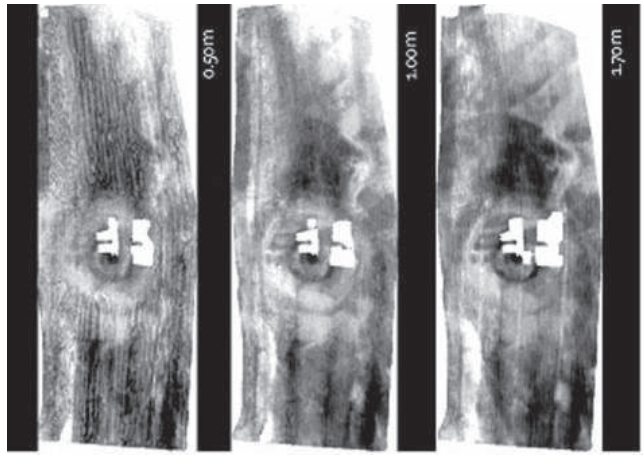

Figure 2: ARP maps at different depths and related sample area

of 10 × 10 m. The samples were analysed with semi-quantitative spot tests to check for the presence of phosphates, carbonates, protein residues and fatty acids (Barba, 2007).

Analysis results for the samples recovered along the two lines show a general pattern of values decreasing from the centre to the exterior of the site. In the case of phosphates, this can be interpreted as decreased intensity of human activities towards the exterior of the circles. In the case of carbonates, a correspondence can be recognized between their presence and the remains of buildings in which plaster was used, which tends to demonstrate high carbonate values.

Samples recovered in the central area (50 × 60 m) also confirmed the pattern for decreasing values from the centre toward the exterior. Carbonates are again related to the presence of wall remains in the central part of the site, a phenomenon recognized also in the GPR data, Fig. 3b.

Phosphate values are demonstrating a dropping tendency progressing from the centre to the outside, this being related to a more intense frequentation of the inner area. The highest values are found to the west and southwest, where radar data have suggested the presence of structures. Nevertheless, phosphates are related to more than just the presence of buildings, for they are the product of human activities, such as food preparation and consumption, animal breeding, waste discarding, and burials. The concentration could be explained therefore by a different use of space here compared to other parts of the site.

In September 2007, three sections of the area were excavated with the aim of verifying these results. Inside the internal ditch, a phase with pits was discovered, damaged by recent agricultural activities. Under this, an interesting earlier layer was found, containing big stones, pottery and

evidence of burning, potentially related to the collapse of some stone buildings. The second test-pit was dug across the smaller ditch in order to locate it precisely and ascertain its real dimensions. The external line of the ditch has been identified, filled with many layers of charcoal and burned stone. On the inner side of ditch, parts of stone structures, partially collapsed, were discovered.

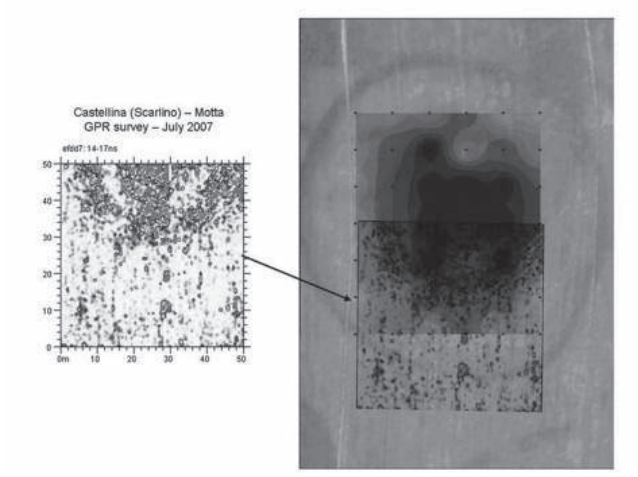

Figure 3 (see color plate): (a) GPR time-slices at estimated depth of 0.65 m. (b) Overlapping of carbonates distribution, vertical aerial photo and GPR time-slice

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